THE AMERICAN MINERALOGIST

JOURNAL OF THE MINERALOGICAL SOCIETY OF AMERICA

VOL. 15 NOVEMBER, 1930 No. 11

A REMARKABLE OCCURRENCE OF THUCHOLITE AND OIL IN A PEGMATITE DYKE, PARRY SOUND DISTRICT, ONTARIO

HUGH S. SPENCE, *Mines Branch,*
*Department of Mines of Canada.**

INTRODUCTORY

In 1928, H. V. Ellsworth described in this Journal[1] an occurrence of a radioactive carbon mineral in a pegmatite dyke occurring on lots 9 and 10 of concession IX in the township of Conger, Parry Sound district, Ontario. For this mineral, Ellsworth has proposed the name thucholite, in place of the older term anthraxolite, which was originally given to a primary carbon from Lake Superior, and which has since been applied more specifically to the anthracite-like carbon of vein-like deposits in the Sudbury district, Ont. The name anthraxolite has also been used generally for the carbonaceous material found at a number of scattered localities in the Pre-Cambrian crystalline rocks (pegmatites) of Canada.

The writer has recently observed an even more remarkable occurrence of thucholite than that described by Ellsworth, the chief points of interest being (1) that the material occurs, in part, in the form of well-defined, cubic crystals, which are apparently pseudomorphic after uraninite, and (2) that the pegmatite carrying the material also contains hydrocarbons both in the form of a rather thin oil, and also as small blebs or droplets of solid, asphalt-like material, both the latter occurring in cavities and cracks in two distinct cross-fracture zones that cross the dyke. Ellsworth remarks in his paper (p. 434) that thucholite and the tar-like hydrocarbon which he found in some Canadian pegmatites had not thus far been found in one and the same dyke, and the occurrence described below seems therefore of added interest.

---

* Published by permission of the Director, Mines Branch.

[1] *Amer. Mineralogist*, Vol. **13**, No. 8, August 1928, pp. 419–41.

LOCATION AND DESCRIPTION OF DEPOSIT

The occurrence described here lies some 50 miles northwest of that in Conger township described by Ellsworth, and is situated on lot 5, concession B of the township of Henvey, Parry Sound District. It lies two miles northeast of Britt station, on the Sudbury-Toronto line of the Canadian Pacific railway, which is the shipping point for the feldspar produced The property is known as the Besner mine.

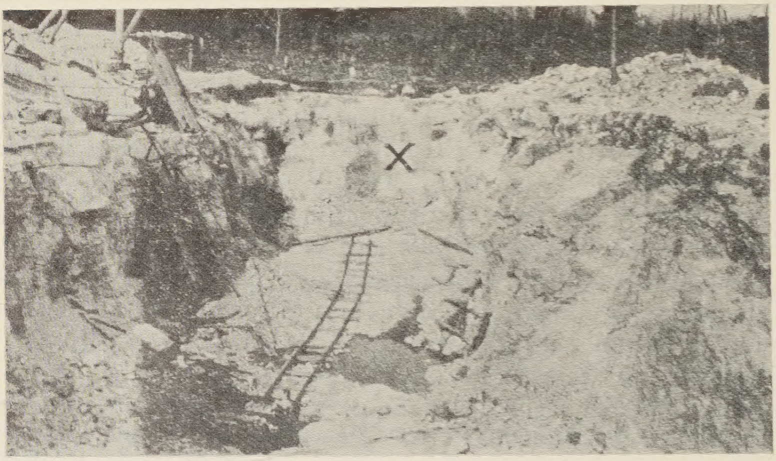

Fig. 1. View of quarry opening at Besner feldspar mine, Henvey township, Ont. Most of the thucholite found in place occurred in pockets along the right (south) wall of the pit (see Fig. 2). One of the oil-bearing zones described in this paper crosses the dyke along the face shown at the far end of the pit (x).

When visited in 1929, the quarry opening consisted of a vertical open pit, 150 feet long by 50 feet wide and 30 feet deep (Fig. 1). The total width of the dyke-mass is about 70 feet: its total length is not known, owing to a heavy drift cover at the east end. The dip is vertical, and the enclosing country rock is biotite gneiss. The gneiss has suffered considerable shattering, being traversed by innumerable cross joints, which have broken it into angular blocks. Thin stringers of pegmatite and white quartz are abundant in the gneiss.

In its general character, the dyke resembles the ordinary run of pegmatites that are found abundantly in the Archean gneisses of eastern Canada. It consists of large crystal masses of light pink, fine- to medium-textured perthite, separated by zones of massive white quartz. Large thin flakes of biotite, altered in great part to chlorite, are scattered in some quantity throughout much of the dyke, but this is the only conspicuous accessory mineral present away from the wall zones. It is in the latter that the minerals described in this paper are chiefly found, although some of them, notably cyrtolite and allanite, occasionally occur in small amount in the feldspar and quartz of the dyke-body proper. There is no tourmaline present, and muscovite and garnet, common minerals in the pegmatites of the Sudbury district, further to the north, occur in comparatively small amount.

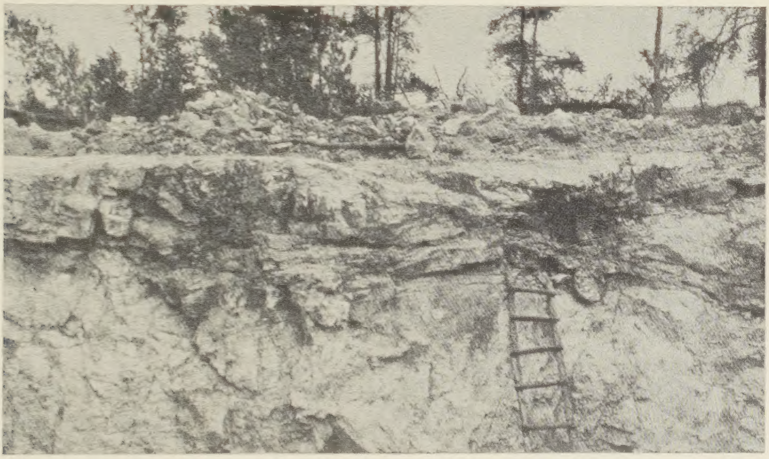

FIG. 2. View of south wall of pit, showing two of the thucholite-bearing pockets.

The following notes on the thucholite and other minerals of the Henvey pegmatite are of a preliminary nature only, since there has not yet been opportunity to have more detailed microscopic and analytical work conducted on the material. The unusual mineral association in this dyke, however, is so interesting that it has been thought worthy of record, pending closer examination and study of the material.

THUCHOLITE

OCCURRENCE

The most remarkable feature of the pegmatite is the presence of a relatively large amount of the carbon mineral, thucholite.

The occurrence of small buttons of coal-like carbon in Canadian pegmatites, on the whole rather rare, is not new. Such material was reported over 30 years ago from pegmatites in the Saguenay district, lower St. Lawrence, in Quebec, where the buttons occur in massive quartz or upon cleavage planes in the feldspar. But at none of the recorded localities is the material present in anything approaching the quantity found in the Henvey dyke.

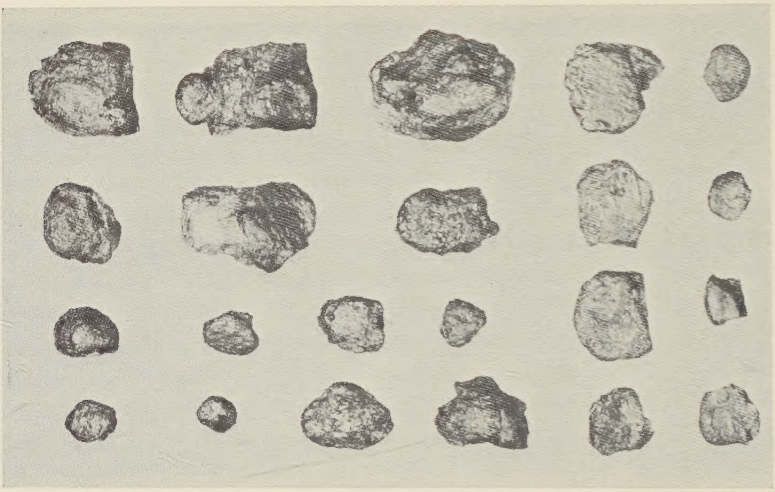

FIG. 3. Specimens of nodular thucholite. Two-thirds natural size. The eight specimens of the two rows on the right have been flattened by pressure, probably while still in a semi-solid state.

Most of the thucholite found occurred near the dyke walls, at or near the surface. Only minor traces of it were noted in the lower part of the pit. It occurs, for the most part, more or less closely associated with radiated groups of a highly-altered, green mineral (Figs. 11, 12) that is now principally chlorite, but which may originally have been a variety of allanite (pyrorthite?). This mineral appears to have been formed between the cleavage planes of shattered oligoclase feldspar, and forms fan-like aggregates. Each group is distinct and has a common radial point which is always uppermost. Several of such groups occur along the south wall of the pit and within ten feet from the surface (Fig. 2). The thucholite is present both in and alongside this chloritized mineral, and also, in greater amount, at the outer (or lower) margin of the groups.

The thucholite occurs in five forms: (1) Irregular massive, filling crevices and cavities. (2) In small, usually rather flattened, bean-like nodules in the chlorite mineral and also as more symmetrical nodules in titanite, biotite and feldspar (Fig. 3). (3) In rough, cubic crystals, often somewhat flattened or distorted, and sometimes with smaller penetration twins growing from the side. The cubes are found sometimes in the massive thucholite and sometimes also partly embedded in the chlorite or titanite. Their form strongly resembles that of the cleveite variety of uraninite, and suggests that they may be pseudomorphic after that mineral (Figs. 4, 5, 6). (4) As more perfect cubic crystals, with sharper outlines, in the feldspar surrounding the chlorite groups: these crystals often exhibit a slight development of the dodecahedron face (Figs. 5, 6). (5) As thin films and minute veinlets in the feldspar and other minerals closely associated with the chlorite. These minerals have evidently been highly shattered, and the carbon has penetrated along the joints and hair-cracks formed in them. The carbon is thus the latest mineral to have been introduced.

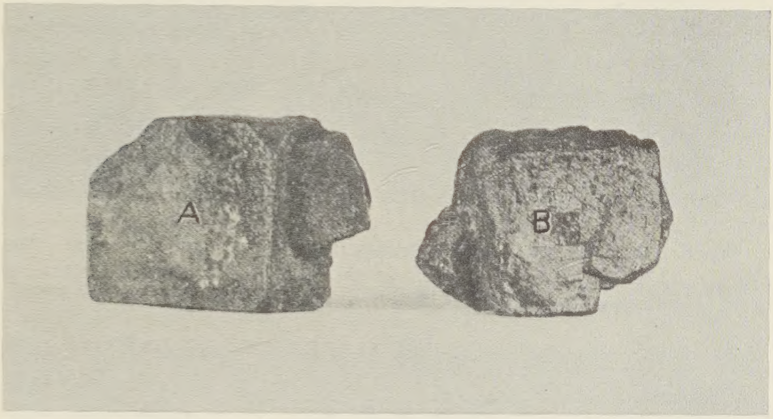

FIG. 4. Uraninite crystal from Wilberforce, Ont. (A), and thucholite crystal from Henvey township (B), showing similarity of form. Both crystals have a smaller penetration twin growing from the side. Seven-eighths natural size.

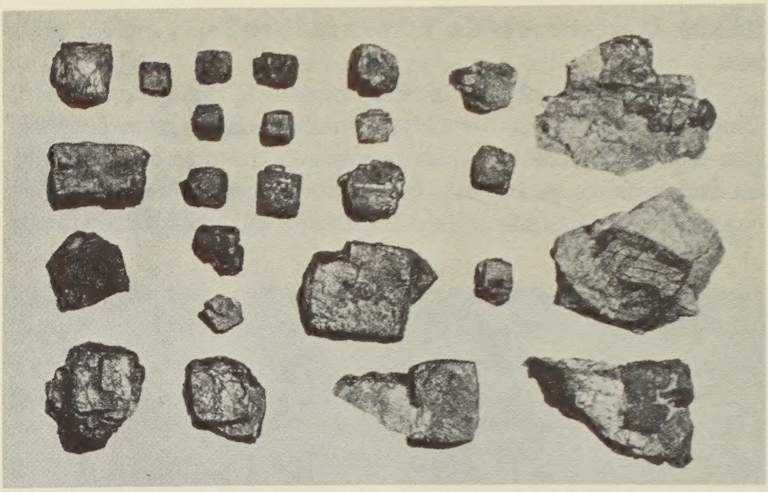

FIG. 5. Specimens of thucholite crystals from Henvey township, Ont. One-half natural size. The three specimens on the right show crystals in a matrix of feldspar and altered titanite.

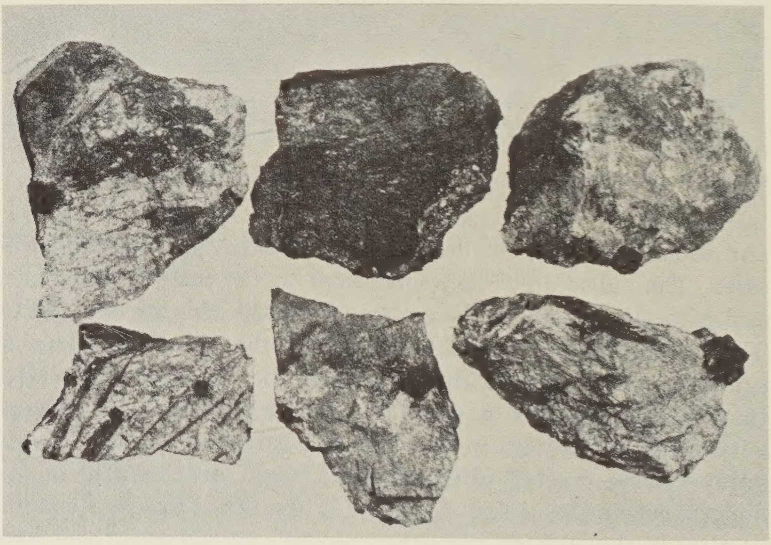

FIG. 6. Crystals of thucholite in feldspar and titanite matrix. One-half natural size. The middle, upper specimen is partly embedded in the altered (chloritized) mineral (pyrorthite?) with which the thucholite is so conspicuously associated, plates of which are also visible in the other specimens.

A peculiar slickensided effect is often noticeable upon the surface of the nodular thucholite, particularly of flattened nodules, the wavy lines characteristic of slickensided surfaces being very pronounced. The same structure sometimes also is seen in the massive thucholite often found enclosing obscure thucholite crystals, the wavy lines then extending radially from the faces of the crystals

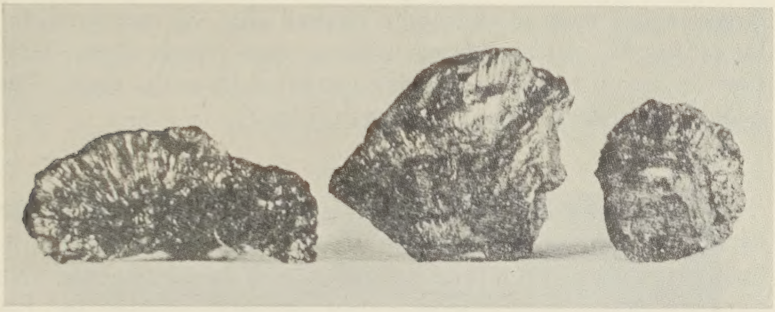

FIG. 7. Specimens of nodular thucholite, showing radial, slickenside striations, due to pressure while the mineral was in a semi-solid state. Three-fifths natural size.

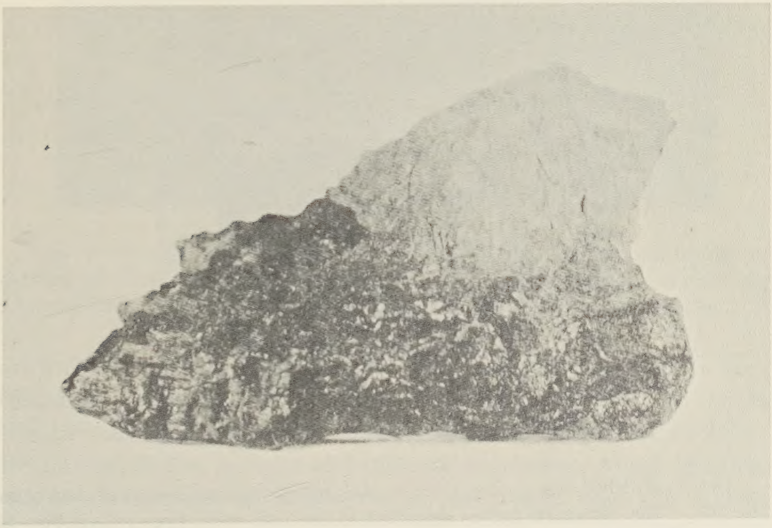

FIG. 8. Mass of thucholite, with adhering feldspar (light). The specimen consists of at least four large, deformed thucholite crystals, embedded in massive thucholite, but this detail is lost in the photograph. Two-thirds natural size.

(Fig. 7). The effect would seem to be the result of later squeezing, probably while the mineral was in a semi-solid state.

Most of the thucholite cubes are small, from $\frac{1}{4}''$ to $\frac{1}{2}''$ in diameter; the largest perfect cube found measured 1″ (Fig. 4). The largest single mass of thucholite secured (Fig. 8) measured $4\frac{1}{2}''$ by $2\frac{1}{2}''$ by 1″, although larger masses were found: these, however, broke up badly while being extracted from the rock. The nodules range from $\frac{1}{4}''$ to 1″ in length (Fig. 3).

CHARACTER

The massive thucholite possesses the characteristics described by Ellsworth for the Conger material. It is jet black, has a brilliant lustre when fresh, and exhibits a conchoidal fracture. No signs of cleavage were observed. It is extremely brittle, and has a sooty, brownish-black streak. Hardness about 4. It is opaque in the thinnest flakes. Specific gravity = 1.57 at 21°C, which is slightly less than that of the Conger mineral.

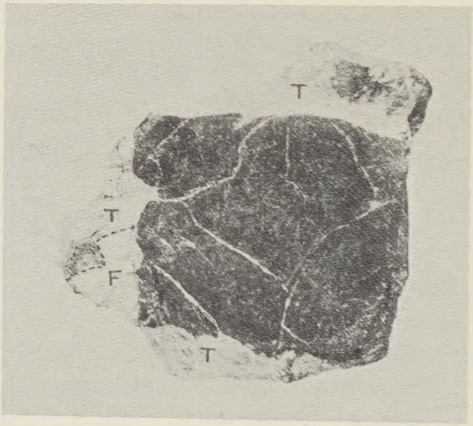

FIG. 9. Polished face of thucholite crystal, with adhering feldspar (F) and titanite (T). The structure figures described in the text and illustrated in Fig. 10 are faintly visible. The strong, irregular white lines are cracks. Magnification $1\frac{1}{3}$ diameter.

The nodular thucholite resembles the massive material, but often has a duller appearance, due to a light film of foreign matter on the fractured surfaces. Large nodules often show a core of rather granular thucholite.

The cubes nearly always have a dull, earthy appearance, even on fractured surfaces, and are evidently composed of non-homogeneous material; this strengthens the theory that they are pseudomorphs. Many of them have a distinct core, which may make up half or more of their mass, of a heavy, black mineral which is probably uraninite. Crystals of uraninite of similar form sometimes occur with all types of the thucholite. Rarely, thin films or crusts of green vanadium salts and of yellow uranium salts occur on fractured surfaces in the massive thucholite surrounding thucholite crystals. The specific gravity of three selected crystals was found to be 1.61, 1.92 and 2.00, at 21°C. In contrast to the nodular and massive thucholite, which becomes friable and breaks up rather readily on weathering, the crystal thucholite is fairly compact and resistant to the weather. The crystals sometimes exhibit traces of obscure octahedral parting.

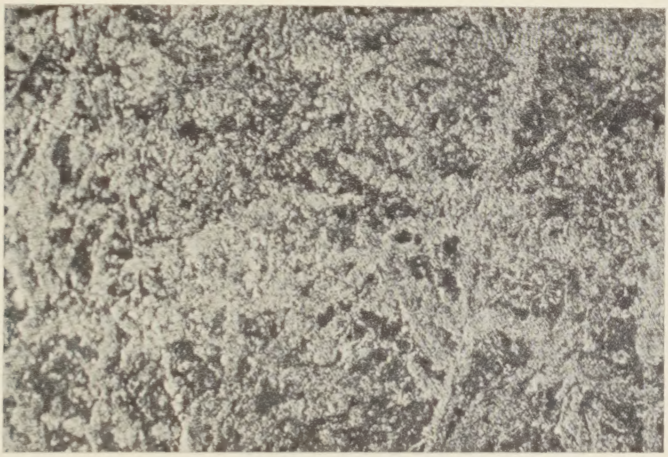

Fig. 10. Portion of polished face of thucholite crystal illustrated in Fig. 9, showing dendrite-like, structure figures of thucholite (light) in process of replacing uraninite (dark). The strong white lines are cracks. Magnification 10 diameter.

A few crystals were found which exhibit a peculiar pressure effect, the upper cube face having been pressed down while the material was soft, so that a portion of the crystal is flattened out and in part depressed, mushroom-wise, down and around the remainder.

In order to determine whether the thucholite possessed any conspicuous structure, a fairly well-formed crystal measuring one inch in diameter, was ground down and polished on one face (Fig. 9). Even to the unaided eye, the polished surface revealed an interesting structure, and this showed up very plainly under a low magnification as a network of interlacing, dendrite-like figures (Fig. 10). These figures evidently represent secondary mineral matter (carbon) penetrating and replacing an original mineral which is presumed to have been uraninite. The massive and nodular thucholite, when ground down and polished as above, showed no trace of structure, being dense and apparently homogeneous throughout.

All types of the thucholite, when polished, exhibit irregular contraction cracks, which lack any definite orientation and which appear to have developed within the material subsequent to deposition. Such cracks are in part open and in part filled by altered titanite or other mineral matter.

The thin films and veinlets of thucholite penetrating feldspar are composed of rather dull, granular, coal-like material. This is porous, as if it had suffered considerable shrinkage in place, the texture being what might be expected if films of oil had penetrated along cracks and been later carbonized.

Composition

Analyses were made both of the crystal and massive thucholite, and, as expected, the results differed rather widely, owing to the fact that clean and apparently homogeneous material could readily be selected in the second case, whereas the crystals proved difficult to free completely of adhering mineral. The crystals, being presumably pseudomorphs, were also expected to contain more ash in the form of residual matter from the original uraninite.

The sample of crystal thucholite comprised portions of fifteen individuals, eight of which averaged ½″ in diameter and seven ¼″. The massive thucholite represented a composite sample of material taken from various places in the pit; only fresh, lustrous mineral was included.

The analyses were conducted by R. A. Rogers, of the Ore Dressing Division of the Mines Branch. Mr. Rogers' report is as follows:

Sample No. 1: Thucholite Crystals

Weight of sample: 23.512 grams.

Material consisted of roughly cubic crystals, or broken pieces of crystals, ½″ size and smaller.

Specific gravity, determined on total material of sample, at 72° F., =1.82.

Moisture at 110° C	2.00
Volatile hydrocarbon[2]	20.19
Fixed carbon	50.82
Ash	26.86
	99.87

Sample No. 2: Massive Thucholite

Weight of sample: 36.791 grams.

Material consisted of irregular, rather flattened fragments, ½″ size and smaller.

Specific gravity, determined on total material of sample, at 72°F., =1.67.

Moisture at 110° C	1.60
Volatile hydrocarbon[2]	19.96
Fixed carbon	61.56
Ash	16.63
	99.75

Moisture was determined by heating a one-gram portion in a platinum crucible in a constant-temperature oven for one hour at 110°C. The sample was cooled over sulphuric acid in a dessicator and weighed. On heating to 230°C, no further loss in weight took place.

Volatile matter was determined on a one-gram sample, powdered to pass 65 mesh. The sample was heated in a platinum crucible, provided with a close-fitting cover, for seven minutes over a Meker burner, cooled and weighed. The total loss in weight, minus the moisture weight determined at 110°C, gave the figure for volatile.

Fixed carbon was determined on the residue from the sample tested for volatile. This residue was placed in an alundum boat and burned in a current of oxygen in a combustion furnace, the CO_2 being absorbed and weighed.

Ash was determined by weighing a one-gram sample of material, crushed to pass 65 mesh, in a silica crucible and burning in a small muffle furnace to constant weight.

Ignition tests on the samples were made with the following results. Fragments of both samples, placed in a muffle at a red heat, ignited easily and burned at first with a yellow flame 1½″ to 2½″ high, indicating the presence of volatile hydrocarbons. Duration of this flame was about 20 seconds. The fragments then burned with a very short blue flame. No decrepitation took place, and the fragments retained their form after cooling.

---

[2] Author's note. While most of this figure probably represents hydrocarbon, a proportion of it possibly is to be assigned to water of composition of the ash residue.

When the samples were powdered and ignited as above, No. 1 burned to a reddish-brown ash, and No. 2 to a greenish-black ash. Under the microscope, both powders are seen to contain a proportion of lighter-coloured particles. When No. 1 powder was burned in a current of oxygen, it had a tendency to fuse into globules.

Under the microscope, the fragments from the ignition test are seen to have a pale, olive-green colour internally, while a mottled brownish-red was noted on the outside. The red colouration was much more pronounced in the No. 1, or crystal sample. The larger pieces still preserve traces of the conchoidal fracture of the fresh thucholite; they are traversed by numerous fine hair cracks. The material is clearly not homogeneous, small flakes of calcined mica or chlorite being visible in No. 1 sample, while No. 2 contained a proportion of almost black mineral.

When tested in the electroscope, the ash from both No. 1 and No. 2 samples was found to be strongly radioactive. Equal weight and surface areas of each sample and of a carnotite standard containing 0.87 per cent U_3O_8 were compared[3] with the following results:

No. 1 was 10.4 times as active as the standard.
No. 2 was 62.5 times as active as the standard.

These results proved rather contrary to what had been expected, as it was thought the crystal material would be more active than the massive. Ellsworth found the ash of the Conger thucholite to have an activity 13.6 times as great as a carnotite standard of 1.55 per cent U_3O_8 content, from which he deduced a U_3O_8 content of 21.08 per cent. By the same method of calculation, the ash of No. 1 sample would contain 9.05 per cent U_3O_8, and that of No. 2 sample, 54.37 per cent. Such calculations for U_3O_8 content, however, do not give dependable results when the uranium content of the sample is much greater than that of the standard.

COMPARISON OF THE HENVEY AND CONGER THUCHOLITE

Ellsworth found for the Conger thucholite described by him, carbon contents of 42.24, 45.18 and 50.48 per cent, respectively. On three different samples, he obtained the following moisture and ash values:

Moisture at 110°C	7.64	8.63	8.40
Ash	24.48	24.20	28.06

[3] Determinations by A. Sadler, Chemical Division, Mines Branch.

Comparing these figures with those obtained for the Henvey thucholite, the widest discrepancy is shown by the moisture content, the Henvey mineral being very much lower in water than the original.

The Conger thucholite, which is described as occurring in close association with uraninite, might be expected to correspond more closely with the crystal than with the massive type from Henvey, which, in fact, it does.

An important difference between the thucholite from the two localities is that Ellsworth found the Conger material to contain no volatile hydrocarbons, whereas the Henvey thucholite contains in the neighbourhood of 20 per cent. This figure, however, was obtained by difference and not by a direct method, and thus may be too high.

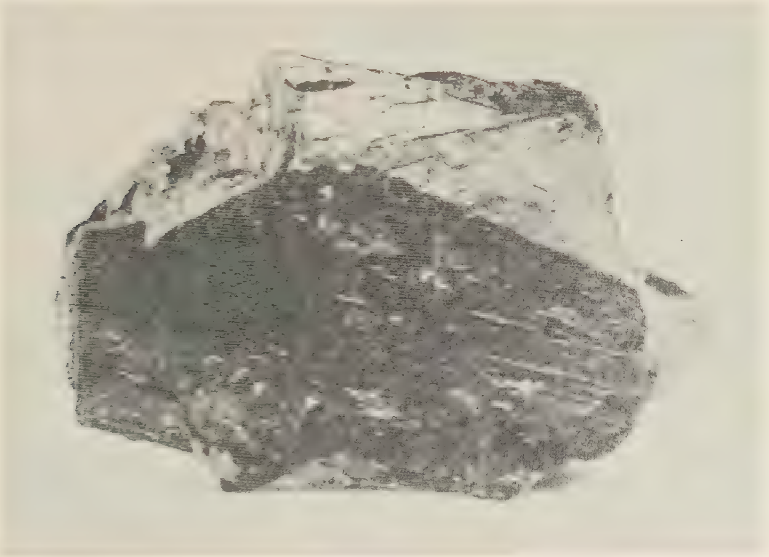

FIG. 11. Platy crystal of the altered, dark-green mineral (pyrorthite?) with which the thucholite is prominently associated, penetrating feldspar (light). The wedge form of the mineral is shown, andal so the longitudinal striations. Two-thirds natural size. (Reverse of Fig. 12.)

The specific gravity (1.57 to 1.67) of the massive thucholite from Henvey, as determined on several samples, is 0.20 to 0.10 lower than that of the Conger material (1.77), while that of the crystal thucholite (1.61 to 2.00) varied from 0.16 lower to 0.23 higher.

The comparative radioactivity of the ash yielded by the mineral from the two localities has already been noted in the preceding section.

MINERALS ASSOCIATED WITH THE THUCHOLITE

As already noted, the thucholite is usually found enclosed in oligoclase feldspar and associated with radiated groups of thin, wedge-shaped plates of a dark green, altered, and often highly-carbonaceous mineral (Figs. 11 and 12) that is now principally chlorite and whose original identity is doubtful. Pending further study, this mineral is provisionally classed as pyrorthite. Other interesting minerals that are closely associated with the thucholite are the following.

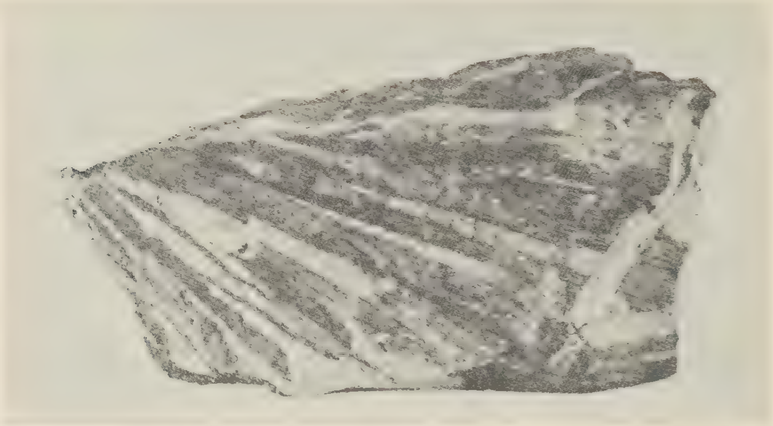

Fig. 12. Specimen showing typical radiating habit of the altered, green mineral (pyrorthite?) with which the thucholite is associated. The plates, which attain a length of 30 inches and radiate fan-wise from a common nucleus, are frequently impregnated with carbon. Thucholite nodules and crystals occur along their margins and sometimes embedded in them. Such an embedded thucholite crystal is visible (x) in the lower, right corner. Two-thirds natural size. (Reverse of Fig. 11.)

Allanite

A dark-coloured, brown to black mineral, that is probably allanite, is fairly common in more or less close proximity to the thucholite. It has a vitreous to resinous lustre and a sub-conchoidal fracture, when fresh. Most of this mineral found was massive, with no traces of crystal outline.

Well-formed crystals, up to 3″ long, of a black mineral, that may be highly-altered allanite, also occur with the thucholite and the same mineral also occurs in small, formless masses in feldspar at various places throughout the dyke. The material of these small masses, while also considerably altered, is fresher than that of the crystals, has a dull, resinous lustre and often so closely resembles dull thucholite as to make it difficult to tell the two substances apart in the rock. The crystals, on the other hand, are matt and earthy on broken surfaces, and the mineral is often so highly altered as to readily slake in water to an earthy powder.

Beryl

A few specimens of massive greenish-blue, glassy beryl were found associated with allanite, titanite and thucholite, and also several small beryl crystals up to 1½″ in length, embedded in feldspar. The mineral is rare.

Biotite

Large plates of biotite occur in some abundance, distributed irregularly through the dyke-mass, and more particularly in its western portion. The plates attain a diameter of 30″, but are seldom over 6″ thick and are usually much thinner. They often contain layers of garnet and martite, that penetrate between the sheets, and also sometimes enclose small nodular masses of martite. More rarely, round nodules of thucholite, up to 1″ in diameter, are found enclosed in the biotite.

Cyrtolite

An almost invariable associate of the massive and nodular thucholite is cyrtolite, which occurs in small masses up to a pound or more in weight. The surface of the masses exhibits well-formed crystals of square prismatic habit, with curved faces. The colour of the mineral is brownish-grey to reddish-brown. It sometimes contains small inclusions of lustrous thucholite.

Occasional small masses of cyrtolite are also common in the body of the dyke, enclosed in feldspar, and unaccompanied by thucholite.

The association of cyrtolite with the thucholite is of interest since Ellsworth records the same association in the dyke in Conger township.

GARNET

Small amounts of granular, reddish-brown garnet, that is probably almandite, occur with the thucholite, usually closely intergrown with the chlorite. Individual crystals are rare, but a few small, deformed ones were observed.

Massive garnet often occurs in wedge-shaped layers, up to 1″ in thickness, between the plates of large biotite crystals, and these layers also include well-formed garnet crystals, some of them ½″ in diameter.

MARTITE

Considerable martite occurs in the dyke, usually in the form of small, nodular masses, up to 1″ in diameter, enclosed in feldspar. Similar nodules, as well as wedge-shaped layers up to ⅛″ thick, also sometimes occur enclosed in large biotite individuals.

PYRORTHITE (?)

The altered mineral, now principally chlorite, that is such a conspicuous associate of the thucholite, has a dark greenish-colour and a greenish streak: with increasing carbon content the latter becomes brown-green. It occurs in broad, flat, platy crystals that attain a length of 30″ and are often 2″ to 4″ wide. The individuals are seldom over ½″ thick and are usually much less (Fig. 11). They occur in radiated groups in feldspar, but without parallel axial arrangement. They have a tapered form, both widening and thickening with increasing distance from the common nucleus from which groups of crystals start (Fig. 12). They also taper laterally to a wedge-like edge. The broad faces are uneven and carry strong longitudinal striations (Fig. 11). Traces of obscure, scaly cleavage parallel to the tabular faces are sometimes evident, but in the main the mineral exhibits uneven fracture. The lustre is dull to earthy. Hardness = 2½ − 3. The crystals are distinctly non-homogeneous and contain considerable pyrite. They often also contain appreciable amounts of thucholite in thin seams between the platy layers. The texture is rather loose.

Dana (6th Ed., p. 523) lists a variety of allanite, high in carbon, —pyrorthite—described by Berzelius from Sweden, with which the Henvey mineral seems to have broad similarity and with which it may possibly be identical.[4]

---

[4] NOTE.—Since the above was written, the writer, through the courtesy of

TITANITE

Another invariable associate of the massive and nodular thucholite is titanite, which occurs in considerably greater amount than cyrtolite. It is rather highly altered and of a light greenish-grey colour. In some cases, the alteration has been so pronounced as to have converted the original mineral into a grey clay, resembling impure kaolin.

The titanite occurs in large irregular masses, which, on breaking, are seen to be made up of an aggregate of broad, platy, wedge-shaped crystals. These exhibit the typical twinning of titanite. The individuals measure up to 2″ across the faces.

Under the microscope, the titanite is seen to often contain small seams and cavities, which are lined with minute crystals, possibly also titanite. It is also full of very small specks of a brown, lustrous mineral, that are probably remnants of fresh, unaltered titanite, and it is frequently traversed by fine, hair-like veinlets of thucholite. Minute black specks of an included black, brilliant substance may also be thucholite.

URANINITE

Uraninite is present in relatively large amount in the mineral assemblage intimately associated with the thucholite. It was not observed elsewhere in the dyke. It occurs rarely in small cubic crystals enclosed in thucholite, the crystals seldom being over $\frac{1}{4}$″ across. The habit suggests that it is to be referred to the variety cleveite. Cubes of apparent thucholite often indicate by their weight that they contain a core of a very heavy mineral that is probably uraninite; and broken crystals, composed externally of thucholite, frequently are seen to be made up in part of uraninite.

Considerable massive uraninite is also present in the form of small veins, which sometimes attain a width of as much as $\frac{1}{2}$″.

Dr. L. J. Spencer, of the British Museum, has been able to secure two specimens of the type pyrorthite from Kararfvet, near Fahlun, Sweden, and has compared the material with that from Henvey. The Swedish mineral consists of small, thin, bladed crystals, penetrating oligoclase feldspar, and is black, lustrous and quite fresh, in contrast to the green, chloritized Henvey mineral. The amount of thucholite present is very small, only a few minute specks being visible under the microscope: these lie in the feldspar, adjacent to the pyrorthite but not within it. While the Swedish and Henvey minerals differ markedly in appearance, the habit of both is similar, and it seems probable that the Henvey mineral is altered pyrorthite.

Both uraninite crystals and massive uraninite are usually bordered by a shell of thucholite, but there is no sharp line of demarcation between the two substances. In both cases, the uraninite is traversed by minute veinlets of thucholite which is apparently in process of replacing uraninite.

The uraninite is usually composed of an outer zone having grey-black colour, dull lustre and conchoidal fracture, and an inner core of more brilliant, black, granular mineral.

The uraninite crystals are sometimes bordered by a zone of brown, resinous mineral that is evidently an alteration product, but whose identity has not been determined. Earthy incrustations of yellow uranium salts frequently line cracks in the feldspar, thucholite and other minerals surrounding uraninite, and a few specimens of uranophane, in radiated groups of lemon-coloured, fibrous crystals having a waxy lustre, were found in similar association.

Note.—The entire assemblage of minerals associated with the thucholite, containing, as it does, much included thucholite in the form of irregular masses, nodules, pellets and minute veinlets, exhibits, in its character, just what might be expected if we suppose the pocketty zones in which such minerals occur to have become saturated with oil which later was carbonized. This hypothesis is supported by the remarkable occurrence of oil in the dyke, as described in the following section.

OIL

The presence of an oily substance in the dyke is of extreme interest, since it suggests at once that both it and the thucholite may have a similar origin.

The oil is present in far smaller amount than the thucholite, and, as far as observed, is confined to two parallel fracture-zones that cross the dyke at right angles. These zones are narrow, only about 12 inches wide, and occur some 40 feet apart. Owing to the pegmatite-gneiss contact being concealed by overburden, it was not possible to determine whether the fractures extend into the gneiss on either side of the dyke, but they do not appear to do so, and there is no evidence of any lateral faulting of the dyke.

The most westerly zone, about midway of the pit, is made up of angular, brecciated fragments of feldspar and quartz, cemented in part by calcite and in part by grey, chalcedonic silica. Numerous angular cavities exist in this breccia, and are lined sometimes with sharp, scalenohedral calcite crystals and sometimes with quartz crystals, upon which were found small crystals of marcasite or pyrite. In the second zone, which crosses the pit near the east face, both quartz and feldspar have been shattered to form thin parallel plates. The crevices between these plates are similarly lined with calcite crystals, upon which sit small crystals of pyrite. Some of the specimens carried, also, among the pyrite crystals, numerous minute, twisted wires or hairs of a bright, greenish-yellow, metallic mineral, that is probably marcasite.

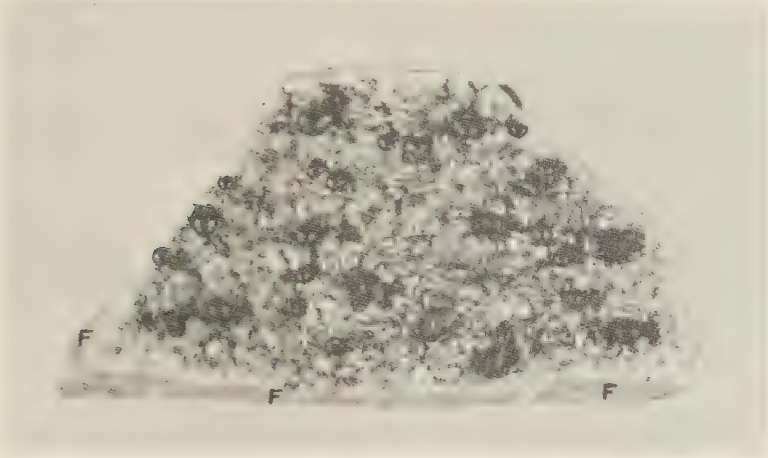

FIG. 13. Small balls of a tar-like mineral (hardened oil) sitting on calcite and pyrite crystals lining a crevice in shattered feldspar (F). The balls range up to ½″ in diameter. Natural size.

Both zones are heavily saturated with a heavy, yellow oil, resembling a thin vaseline. Water, trickling down the face, carries the oil from freshly-broken surfaces to the sump, where it forms a conspicuous film. The oil has the characteristic odour of crude petroleum. On exposure, it soon becomes viscous and extremely sticky.

In addition to the thin oil, there are present in the cavities and crevices of the shattered rock, and sitting upon the calcite or quartz, numerous small, pea-like balls of hardened oil (Fig. 13). In freshly-broken rock, these have a pale, olive-green colour and are soft and tacky, resembling elaterite. On exposure, they gradually harden, first to a rubbery consistency and finally to a hard, pitch-like substance. In the hardening (oxidation) process, they change colour, darkening to brown and finally to black. Films of the oil undergo exactly the same change. The balls range in size from small specks to as much as ½″ in diameter. They are sometimes covered with a coating of pyrite or marcasite crystals.

It was not possible to collect a sufficient amount of the thin oil or of the hardened products to provide material for a complete laboratory investigation. A small number of the pea-like balls were, however, secured, and these have been examined in the Fuel Research Laboratories of the Mines Branch. The following report on the material has been furnished by the Superintendent of the Laboratories:

> The specimen submitted comprised several pea-like lumps of both hard and soft material. The hard lumps were of a brittle, resin-like nature, while the soft lumps were of a gummy, rubbery consistency.
>
> Specific gravity: 1.000 to 1.086. The higher figure was for the largest hard lump, about the size of a large pea, while the average of nine smaller lumps was 1.021.
>
> Solubility tests were made in several different solvents. Selected lumps were found not soluble in acetone and methyl alcohol and only partially soluble in petroleum ether, carbon bisulphide, benzol, sulphuric ether and chloroform. The proportion of the softer, gummy material soluble in chloroform was approximately half, and the refractive index of the chloroform extract was 1.638 at 36°C. (1.645 at 15.5°C.).
>
> When heated at 107°C. for two hours in a moisture determination oven, the loss in weight was 0.8 per cent and the material did not melt.
>
> The ultimate analysis of the dried gummy material yielded:

	Dry basis	Ash-free basis
Carbon	81.48	86.76
Hydrogen	11.46	12.16
Ash	5.75	—
	98.69	98.92

> Ratio of carbon over hydrogen = 7.135.
>
> *Remarks:* The rubbery nature of the material resembles that of elaterite, the specific gravity of which is listed as ranging from 0.90 to 1.05, but the sample was not sufficient to determine to what extent the physical and chemical properties resemble those of elaterite or other (natural or polymerized) organic substances, or to decide definitely its exact nature.

SOURCE OF THE OIL AND THUCHOLITE CARBON

Two questions of great mineralogic interest are: (1) the source of the oil and thucholitic carbon in the dyke, and (2) whether any relationship exists between the oil and the thucholite.

No trace of oil, or of its solid, asphalt-like derivatives, was noted in place outside of the two oil-saturated, cross fracture zones. No thucholite was observed in these zones. The oil zone midway of the pit can now only be seen in a thin strip of pegmatite remaining on the north wall, at a point opposite the thucholite occurrences in the south wall and in the lower part of the pit. The zone probably extended across the pit, in the same manner as that in the east face, but water and broken rock prevented an examination of the pit floor and the zone is not visible in the south wall. In the case of the second oil zone, that crosses the dyke on the east face, a pocket of thucholite, with some uraninite and titanite, was found almost in the middle of the dyke and close to the oil zone but not visibly connected with it.

No data are available on what may have been the distribution of thucholite in the dyke-mass now worked out. The quarry, when first visited, had reached a depth of 30 feet, the pegmatite having been mined out almost to the gneiss wall on the north side. Along the south wall, however, a strip of pegmatite about 8 feet wide remains in place, and it was in this, at a depth of 6 to 8 feet below the surface, that most of the thucholite found was obtained. No thucholite was noticed in place in the floor of the pit. It therefore seems that the thucholite is not disseminated irregularly throughout the dyke-mass, but that it tends to occur in proximity to the oil zones. This naturally would suggest some relationship between the oil and the thucholite, *i.e.*, that the thucholite has been formed from the oil. The fact that the thucholite is so often found in cubic crystals having the typical form of uraninite, and that the massive thucholite frequently occurs associated with uraninite, prompts the theory that the thucholite owes its formation to radioactive emanations from uraninite acting on oil that has penetrated the dyke-mass adjacent to the oil-saturated fracture zones, with the formation of carbon replacing uranium. That carbon, with an atomic number of 6, should replace uranium, the element with the highest atomic number, seems remarkable. Where uraninite has been incompletely (externally) altered to thucholite, the supply of oil may be regarded as having failed. Where massive thucholite encloses thucholite crystals, an excess of oil was probably present, which, however, radioactivity of the original uraninite nucleus sufficed to alter.

If the above theory be correct, the thucholite cannot be regarded as a primary mineral of the pegmatite, (as concluded by Ellsworth for the Conger mineral), and must, indeed, be one of the last minerals to have formed.

No theory is advanced for the source of the oil hydrocarbon present in the cross fracture zones. No younger (Palæozoic) sediments from which oil seepages might possibly have entered these zones occur in the vicinity of the dyke, nor is the presence of such sediments anywhere in the immediate district indicated on recently-published, geological maps[5] of the region. The entire area covered by these maps is underlain by rocks of Pre-Cambrian age, which, in the immediate vicinity of the deposit, consist of granite, quartz-syenite and gneiss. It is possible, of course, that younger sediments may have existed and have since been removed by erosion.

If the oil be of direct pegmatitic origin, it might be expected to occur irregularly in the dyke-mass proper and not alone in the brecciated zones, as seems to be the case. This, however, does not necessarily preclude an igneous origin, since the mass of the dyke, which is a very tightly frozen rock, may have provided no channels in its upper, already cooled portion for the penetration of the oil. The loose, brecciated ground of the fracture zones would provide such channels, and from these the oil might have traveled into contraction cracks adjacent to the walls—that is, into the zones where most of the thucholite, with its associated uraninite, titanite, cyrtolite, etc., is found.

SUMMARY

The above notes describe what is believed to be the most important occurrence of pegmatitic carbon (thucholite) on record.

In addition to the interest due to the comparatively large amount of thucholite present in the dyke, its occurrence in the form of cubic crystals, which are presumably pseudomorphs after uraninite, is remarkable. The general occurrence of the thucholite indicates that it is not a primary constituent of the pegmatite, but that it has been introduced at a later stage, possibly in the form of oil. It was probably one of the last minerals to form, its deposition coinciding with severe alteration of the titanite, allanite, etc., with which it is often associated. The fact that it contains about 20 per cent of volatile hydrocarbons suggests that the mineral has not reached stable form.

Of added interest is the presence in the dyke of a hydrocarbon in the form of a petroleum-like oil, and of small pea-like bodies of a substance resembling elaterite.

---

[5] *Geol. Surv. Can.*, Maps Nos. **220A, 221A, 238A, 239A.** These maps embrace an area of over 1,500 square miles, lying to the northwest of the deposit, which is situated near the southeast corner of Map No. **239A** (Key Harbour Sheet).

GALLIUM IV. OCCURRENCE OF GALLIUM IN ZINC MINERALS[1]

Jacob Papish and Chester B. Stilson,
Cornell University, Department of Chemistry.

Introductory

Gallium was discovered by Boisbaudran[2] in 1875 as a result of a chemical examination of zinc blende from Pierre-la-Fitte, Valley of Argeles in the Pyrenees. In a later publication Boisbaudran[3] announced that blendes from Schwarzenberg, Bensberg, Asturies, Mandesse and Sweden also contained gallium, while a blende from Vieille-Montagne did not contain it. Cornwall[4] found that gallium was present in blendes from Pierre-la-Fitte; Santander, Spain; Friedensville and Phoenixville, Pennsylvania; Joplin, Missouri; Warren, New Hampshire and Ellenville, New York; and that specimens of blende from Roxbury, Connecticut, and from Mine Hill, New Jersey, did not contain this element. Bartlett[5] stated, in a manner not very convincing, that he had obtained a test for gallium in some low grade sulphurets from the Iron Silver Mine of Leadville, Colorado. Hartley and Ramage[6] reported the presence of gallium in blendes from Pierre-la-Fitte; Bensberg; Santander; Alston Moor, Cumberland; Tipperary, Ireland; Zellerfeld, Saxony; Chemnitz, Hungary; Matlock, Derbyshire; Rio Tuerto, Spain; and Laxey, Isle of Man; and not in blendes from Freiberg, Saxony, and from Ravenswood, Queensland, Australia. Rimatori[7] examined blendes from Bena de Padru, Montevecchio, Nassau, Nieddoris, Argentiera della Nurra, Rio Ollorchi, Rosas, and Riu Planu Castangais, and found that those from Montevecchio and Bena de Padru contained gallium. Urbain[8] reported that of the sixty-four blende specimens examined by him five did not show spectral lines of gallium. He named five localities from which the galliferrous blendes came: Webb City, Missouri; Stolberg, near Aix la Chapelle; European Turkey; Raibl, Carinthia; and Mexico. Cerdan[9] examined sixty-eight samples of Spanish blende and found gallium in sixty of them. Hillebrand and Scherrer[10] reported gallium in sulphides from Sunset, and Frisco, Idaho; Missouri, and Australia.

---

[1] The investigation upon which this article is based was supported by a grant from the Heckscher Foundation for the Advancement of Research, established by August Heckscher at Cornell University.

[2] Boisbaudran, *Compt. rend.*, **81**, 493 (1875).

[3] Boisbaudran, *Ibid.*, **82**, 1098 (1876).

[4] Cornwall, *Amer. Chem. Jour.*, **2**, 44 (1880).

[5] Bartlett, *Jour. Soc. Chem. Ind.*, **8**, 896 (1889).

[6] Hartley and Ramage, *Jour. Chem. Soc.*, **71**, 533 (1897).

[7] Rimatori, *Atti. d. Reale Accad. d. Lincei*, Series 5, **13**, 1, 277 (1904).

[8] Urbain, *Compt. rend.*, **149**, 602 (1909).

Cornwall[11] reported that he found no gallium in specimens of calamine from Friedensville, Pennsylvania, and Sterling, New Jersey, as well as in a sample of zincite from Franklin Furnace, New Jersey.

Method of Analysis

As far as it can be ascertained from recorded data the investigators just referred to depended upon spectroscopic methods for identifying gallium. The method most generally employed was the one in which the high-voltage spark was the means of spectral excitation. Hillebrand and Scherrer[12] made use of the carbon arc. The spark which was undoubtedly of the low-wattage type has drawbacks which made impossible the detection of very small traces of gallium in some of the zinc minerals.[13] In the present work the arc method of excitation was employed for the detection of gallium. This method, which was described in the first article of this series,[14] consisted in placing a small quantity of the pulverized zinc mineral between electrodes of artificial graphite, passing the arc discharge, and photographing the spectrum with the aid of a quartz spectrograph of the Littrow auto-collimating type. The spectral lines λλ4172.0 and 4033.0 served to establish the identity of gallium. These lines are of high sensitivity and they lie in a range where interference caused by lines of other elements is not very serious. This is especially true of λ4172.0, since λ4033.0 is overlapped by spectral lines of manganese and iron, commonly associated with zinc in minerals. But even λ4172.0 was found at times inadequate. When graphite electrodes are used for the production of the arc in air, cyanogen bands are unavoidably present in the spectrograms, and λ4172.0 lies within one of these bands. If this line of gallium is of low intensity it will be drowned, so to speak, in the brilliance of the cyanogen band, and as a result minute traces of gallium in zinc minerals will not be detected. To remedy this, recourse was made to silver electrodes whenever a spectrographic examination with the aid of graphite electrodes did not reveal the presence of gallium. The silver electrodes were admirably suited to this purpose: they were free from gallium and they gave no background of continuous spectrum in the range of λ4172.0.

---

[9] Cerdan, *Anal. Fis. Quim.*, **12**, 80 (1914).

[10] Hillebrand and Scherrer, *Jour. Ind. and Eng. Chem.*, **8**, 225 (1916).

[11] *Loc. cit.*

[12] *Loc. cit.*

[13] Papish and Kennard, "The High-Wattage Spark in Spectral Chemical Analysis." (*Not published*).

[14] Papish and Holt, *Jour. Phys. Chem.*, **32**, 142 (1928).

RESULTS

In the tables containing results of the present investigation "*v*" is used to designate that the spectral line was plainly visible, "*f*" that it was faint and "*vf*" very faint. Designation was omitted when the spectral line could not be detected because of interference of lines of other elements. This applies in very many cases to λ4033.0, which, as already mentioned, is overlapped by spectral lines of manganese and iron.

SPHALERITE. Eighty specimens of sphalerite were examined for the presence of gallium and the results are recorded in Table I. As seen from this table all of them contained gallium. Sphalerite No. 52 was associated with dolomite, No. 64 with fluorite and quartz, and No. 73 with magnetite. Sphalerite No. 35 was a fossil shell variety occurring in Tully limestone at Moravia, New York.

TABLE I

GALLIUM LINES IN SPECTROGRAMS OF SPHALERITE

Sphalerite No.	Place of Origin	λλ 4172.0	4033.0
1	Sullivan Mine, Kimberley, British Columbia	vf	
2	Lucky Jim Mine, Sandon-Kaslo, British Columbia	vf	
3	Bell Mine, Beaverdell, British Columbia	vf	
4	Prosperity Mine, Marmot River, British Columbia	vf	
5	Mohawk Mine, New Hazelton, British Columbia	vf	
6	Geneva Lake Mine, Geneva Lake, Ontario	f	
7	Montauban, Quebec	f	
8	Quyon, Quebec	f	
9	Mexico	v	
10	Nogales, North Mexico	vf	
11	California	v	
12	Central City, Colorado	f	

TABLE I (*Cont.*)

GALLIUM LINES IN SPECTROGRAMS OF SPHALERITE

Sphalerite No.	Place of Origin	λλ	
		4172.0	4033.0
13	Kokomo, Colorado	v	
14	Nevadaville, Colorado	f	
15	Moyer Mine, Leadville, Colorado	f	
16	Glacier Lake, near Boulder, Colorado	vf	
17	Jo Reynolds Mine, Idaho Springs, Colorado	f	
18	Roxbury, Connecticut	f	
19	Success Mine, Wallace, Idaho	vf	
20	Dubuque, Iowa	v	
21	Near Baxter Springs, Kansas	f	
22	Near Baxter Springs, Kansas	v	
23	Marion, Kentucky	v	
24	Ottawa County, Oklahoma	v	v
25	Rockport, Mass.	f	
26	Trout Mt. Mine, Missoula County, Montana	vf	
27	Joplin, Missouri	v	f
28	Joplin, Missouri	v	v
29	Webb City, Missouri	v	
30	Freiberg, Nevada	v	
31	Franklin Furnace, New Jersey	vf	
32	Kelly, New Mexico	v	
33	Hanover, New Mexico	vf	
34	Edwards, New York	f	f
35	Moravia, New York	v	
36	Niagara Falls, New York	v	
37	Rochester, New York	f	
38	Rossie, New York	v	
39	Tiffin, Ohio	f	
40	Centerville, Pennsylvania	v	
41	Mt. Joy, Lancaster County, Pennsylvania	v	
42	Wheatley Mines, near Friedensville, Pennsylvania	v	v
43	Ridgebury P. O., Pennsylvania	v	
44	Beaver County, Utah	v	
45	Judge Mine, Utah	v	
46	Austinville, Virginia	vf	
47	Bonsack, Virginia	v	
48	Bonsack, Virginia	f	
49	Wisconsin	v	
50	Raibl, Carinthia	f	
51	Přiʹbram, Bohemia	v	
52	Bleistadt, Bohemia	f	
53	Alston, Cumberland, England	v	
54	Cumberland, England	f	

TABLE I (*Cont.*)

GALLIUM LINES IN SPECTROGRAMS OF SPHALERITE

Sphalerite No.	Place of Origin	λλ 4172.05	 4033.01
55	Cumberland, England	v	
56	Cornwall, England	vf	
57	Schauenslund, Baden	vf	
58	Bodenmais, Bavaria	vf	
59	Kaiser Wilhelm Shaft, Clausthal, Germany	f	
60	Neudorf, Germany	f	
61	Prussia	f	
62	Steefe Sea, Silesia	f	f
63	Freiberg, Saxony	vf	
64	St. Christopher Mine, Schwarzenberg, Saxony	vf	
65	Schwarzenberg, Saxony	f	
66	Schwarzenberg, Saxony	v	
67	Eschborich Mine, Moresnet, Belgium	f	
68	Chemnitz, Saxony	v	
69	Kapnik, Hungary	v	
70	Bottino, Tuscany, Italy	vf	
71	Felsö-bánya, Roumania	f	f
72	Rodnon, Transylvania	f	
73	Picos De Europa, Santander, Spain	vf	
74	Binnenthal, Switzerland	f	
75	Yechigo, Japan	f	
76	Zeekan, Tasmania	f	
77	Tzumeb, Southwest Africa	v	
78	Pierre-la-Fitte, Pyrenees	v	
79	Montserrat, near Pasna, Bolivia	v	v
80	Braubach-on-Rhine	vf	

CALAMINE. The spectrographic test was applied to ten samples of calamine. These samples came from the following localities: Leadville, Colorado; Elkhorn, Montana; Joplin, Missouri; Branby, Missouri; Wentworth, Missouri; Ogdensburg, New Jersey; Organ Mountains, Dona Ana County, New Mexico; Friedensville, Pennsylvania; Bleiberg, Carinthia; Santander, Spain; La Duchessa, Sardinia, and Malfidano, Sardinia.

In all cases the gallium lines λλ4172.0 and 4033.0 could not be detected.

SMITHSONITE. Two specimens of this mineral, one from Marion, Kentucky, and one from Cerro Gordo District, Inyo County, California, were subjected to arc excitation. The spectrograms in both cases did not contain gallium lines.

Zincite. The zincite examined came from Franklin Furnace, New Jersey. The gallium lines were not visible in its spectrogram.

Hydrozincite. Nine specimens of hydrozincite were examined. The localities from which they came are as follows: Cerro Gordo District, Inyo Co., California; Hickory Cave Mine, Marion Kentucky; Ely, Nevada; Good Springs, Lincoln County, Nevada; Deming, New Mexico; Bethlehem, Pennsylvania; Raibl, Carinthia; Bleiberg, Carinthia; and Malfidano, Iglesias, Sardinia. In all cases the gallium lines in question were absent.

Gahnite. Five specimens of this mineral from as many different localities were examined and the results are recorded in Table II. Gahnite No. 1 was associated with pyrites.

Table II

Gallium Lines in Spectrograms of Gahnite

Gahnite No.	Place of Origin	λλ	
		4172.0	4033.0
1	Charlemont, Mass.	f	
2	Franklin Furnace, New Jersey	v	
3	Bodenmais, Bavaria	v	
4	Fahlun, Sweden	v	
5	Orijarri, Finland	v	

Hopeite. Hopeite from Franklin Furnace, New Jersey, on spectrographic examination was found to be galliferous: In its spectrogram λ4172.0 was faintly visible and λ4033.0 very faintly visible.

Parahopeite. A specimen of this mineral from the H. B. Mine, Salmo, British Columbia, upon spectrographic examination gave the following results: λ4172.0, faint, and λ4033.0, very faint.

Adamite. A specimen of adamite from Cap Garonne, Dept. du Var, France, showed the gallium line λ 4172.0 distinctly; λ 4033.0 was not visible because of interference of lines of other elements. Another specimen from Laurium, Greece, showed λ4172.0 faintly.

Goslarite. Two specimens of this mineral were examined spectrografically and no gallium lines were observed. The specimens came from Butte, Montana, and from Goslar, Harz, Germany.

Hodgkinsonite from Parker Mine, New Jersey, showed no gallium lines.

HARDYSTONITE. The specimen examined came from Franklin Furnace, New Jersey. The spectrogram did not contain the lines of gallium.

CLINOHEDRITE from Franklin Furnace, New Jersey, showed no gallium lines on spectrographic examination.

SUMMARY

The arc spectrographic method for the detection of gallium was applied to a number of zinc minerals with the following results:

All specimens of sphalerite, eighty in number, were found to be galliferous. The same is true of five specimens of gahnite, one specimen of hopeite, one of parahopeite and two specimens of adamite.

Gallium lines were absent in the spectrograms obtained from ten specimens of calamine, two of smithsonite, one specimen of zincite, nine specimens of hydrozincite, two of goslarite, and one specimen each of hodgkinsonite, hardystonite and clinohedrite.

A PRELIMINARY INVESTIGATION OF SOME SEDIMENTS FROM JAMES RIVER, VIRGINIA.*

MARCELLUS H. STOW, *Washington and Lee University.*

Much has been written on finding outcrops of rocks by tracing heavy minerals found in stream sands derived from them.

The purpose of this paper is just the opposite; it is to predict the kinds of heavy minerals that would be found in the stream sands, from the type of rock found in the drainage area. In other words, to present definite evidence of the presence or absence, in the sands derived from these areas, of minerals characteristic of the rocks known to exist there.

Besides determining the various types of minerals found and their place of addition to the sediments, an attempt has also been made to determine the persistence of them by an approximate percentage estimation.

The writer makes no claim for completeness in this study. It was done primarily with the idea of obtaining a brief general survey rather than carry on a thorough investigation, and it is believed that the following identifications and approximate percentages indicate a close relationship between the heavy minerals of the rocks of the region and those of the river sands. It is admitted that a more thorough investigation would be desirable.

The area chosen for study extends along the James River in Virginia, from the vicinity of the town of Vesuvius on the North Branch, and Clifton Forge on the main James River, to a point five miles below Lynchburg; thus covering a drainage area consisting of sedimentary rocks from Cambrian through Devonian, Pre-Cambrian intrusives and extrusives, and crystalline schists.

Space does not permit of a detailed description of the field and laboratory methods. It will suffice to briefly summarize these.

Specimens were collected from the shore of the river at intervals of several miles, at the normal water level and a few hundred feet below the mouth of a tributary stream draining a rather large area. No attempt was made to do accurate sampling; just an average sample picked at random was selected.

The laboratory procedure consisted of first removing the clay and fine material by washing the specimen several times with water and dilute hydrochloric acid. After drying, the material was sieved through coarse bolting cloth and the finer separate saved for study. The heavy minerals were separated by means of bromoform having a specific gravity of 2.87. Percentage figures were obtained by rough mineral counts in a field containing a sufficient number of grains to give fairly accurate results.

---

* Presented before the Geological Section of the Virginia Academy of Science at Staunton, May 1929.

At Lick Run the drainage is entirely from sedimentary rocks (sandstones, shales, and limestones) of Cambrian, Ordovician, Silurian, and Devonian ages. Minerals found in this sample were: limonite 96%, ilmenite 3, and tourmaline 1%. The high percent of limonite is accounted for by the fact that the stream entering the James River at this locality drains a region containing many mines of Oriskany limonitic iron ore. It is probable that this high percentage of limonite reduces the number of heavy mineral species that are found. However, it indicates the presence of limonite deposits of greater extent than would commonly be found in sedimentary rocks.

At Eagle Rock, the drainage and geological conditions are exactly the same as at Lick Run, hence we would expect to find heavy minerals of the same types and in about the same amounts. This is confirmed by the following statistical results: limonite 91%, ilmenite 5, tourmaline 1, zircon 2, and rutile 1%. The presence of zircon and rutile here and their absence at Lick Run is not considered to be of any particular significance because of the rather common occurrence of these minerals in sedimentary rocks. Examination of another specimen of sand from the first locality would likely show their presence.

At Sherwood Station the James River has received sediments from the same areas as at Lick Run and Eagle Rock, but in addition drainage has been received from regions containing hypersthene granodiorite and the Marshall granite. The latter consists of pink to green granite and quartz monzonite injected by a pegmatite with blue quartz. Common heavy minerals to be expected from this association would include a small amount of amphibole, zircon, tourmaline, and biotite. The hypersthene granodiorite has been altered in places to unakite; it is also cut by dikes of ilmenite and nelsonite. From this occurrence we should expect amphiboles and pyroxenes, zircon, tourmaline, epidote, ilmenite, and biotite. Mineralogical examination gave the following results: ilmenite 45%, limonite 42, tourmaline 5, zircon 5, amphiboles and pyroxenes 2, and epidote 1%. Biotite was not found. This is not surprising inasmuch as biotite does not withstand weathering and transportation and is not commonly found in sediments.

At Wilson Falls drainage has been from the sedimentary rocks mentioned, from the hypersthene granodiorite of the Irish Creek district where tin veins occur, and in addition, from the Catoctin greenstone which consists of metabasalt lava flows and volcanics altered to amygdaloidal and schistose epidote-chlorite amphibolite. Hence, the common heavy minerals that could be expected are amphiboles and pyroxenes, zircon, tourmaline, biotite, epidote, ilmenite; possibly cassiterite, limonite, and chlorite. A study of this sample gave the following results: limonite 77%, ilmenite 15, zircon 3, tourmaline 2, amphibole and pyroxene 2, and epidote 1%. No cassiterite or chlorite was found. This locality is on the South Branch of the James River and unites with the main river at Balcony Falls, from which point the next sample was obtained.

At Balcony Falls no drainage has been received from regions different from those of the foregoing, so no particular change in the heavy minerals should be found. Eighty-eight percent of limonite, 6 of ilmenite, 1 of epidote, 1 of zircon, 1 of tourmaline and 3% of leucoxene confirm this deduction. The addition of leucoxene to the list is probably due to alteration of ilmenite. The absence of amphiboles and pyroxenes may be due merely to the fact that they are present in such small amount that they were not observed in the material examined.

At Rocky Row Run drainage from all previously described areas is present, but a much greater area of the hypersthene granodiorite has been drained. Here this rock contains a high percentage of garnet which should be expected to appear in the stream sediments. Study of the sand from the river gave the following results: limonite 66%, ilmenite 18, fine micaceous grains 5, garnet 3, leucoxene 2, tourmaline 1, zircon 1, epidote 1, amphibole and pyroxene 1, rutile 1, and kyanite 1%. The micaceous material comes probably from the schistose part of the Catoctin greenstone which is here exposed over a large area.

At Pedlar River drainage from the Lovingston granite gneiss has been added to that from the other localities. This is a biotite-quartz monzonite augen gneiss, and should contribute nothing new to the list of heavy detrital minerals. A study of this sample showed: 49% leucoxene, 37 ilmenite, 6 zircon, 3 epidote, 2 tourmaline, 1 muscovite, 1 amphibole and pyroxene, and 1% garnet. No limonite was in the sample studied, doubtless due to its elimination by attrition during transportation, as this locality is more than 20 miles distant from the nearest deposit of limonite. The high percentage of leucoxene may be due merely to conditions of concentration or to increased supply from the Lovingston granite gneiss, or to another exposure of the hypersthene granodiorite.

Drainage into the river at Mt. Athos adds several significant members to the list of formations contributing heavy minerals to the sands of the river. These formations include: the Lynchburg gneiss—a mica gneiss and mica schist in part garnetiferous; the Schuyler Soapstone—soapstone, amphibolite, peridotite; and pyroxenite intrusive into the Lynchburg gneiss; the Cockeysville marble—a marble with mica and graphitic layers; greenstone volcanics—basic lava flows altered to schistose and amygdaloidal epidote amphibolite; and the Wissahickon schist—a chlorite muscovite schist, garnetiferous biotite schist locally containing staurolite, sillimanite, and kyanite. Heavy minerals found were: micaceous material 41%, ilmenite 28, muscovite 10, staurolite 5, leucoxene 5, epidote 3, amphibole and pyroxene 3, kyanite 3, zircon 1, and garnet 1%. It will be seen that staurolite is found at this locality but not previously. This was probably derived from the Wissahickon schist. No sillimanite, tourmaline, or rutile were identified. As at Pedlar River, no limonite was found, probably for the same reason as for its absence at that locality.

From the foregoing the following conclusions may be drawn:

First. In a sediment containing a great preponderance of some heavy mineral, such as limonite, other minerals may be difficult or impossible to isolate.

Second. Limonite will not be transported any great distance from its source.

Third. Local variation of wave and current effects and the conditions under which collection is made will greatly influence the percentages of the minerals found.

Fourth. Sometimes such common detrital minerals as tourmaline and zircon are not found in a small amount of material under observation.

Fifth. A greater variety of minerals is found with an increase in mineral complexity of the rocks of the drainage area.

LOCALITIES FROM WHICH SPECIMENS WERE OBTAINED AND PERCENTAGES OF HEAVY MINERALS FOUND AT EACH

Locality	Limonite	Ilmenite	Tourmaline	Zircon	Rutile	Amphibole and Pyroxene	Epidote	Leucoxene	Garnet	Kyanite	Fine Micaceous Grains	Mica	Staurolite		Total Number Heavy Mineral Species	Total Percent of HeavySeparates by Weight
Lick Run	96	3	1												3	5
Eagle Rock	91	5	1	2	1										5	5
Sherwood Station	42	45	5	5		2	1								6	1
Wilson Falls	77	15	2	3		2	1								6	5
Balcony Falls	88	6	1	1			1	3							6	25
Rocky Row Run	66	18	1	1	1	1	1	2	3	1	5				11	5
Pedlar River		37	2	6		1	3	49	1			1			8	12
Mt. Athos		28		1		3	3	5	1	3	41	10	5		10	10

Sixth. Most of the minerals added to the sediment persist for many miles below their source.

To the best of the writer's knowledge this investigation represents the first work in sedimentary petrography in Virginia west of the Piedmont Province. There are many opportunities for investigation of sediments, both consolidated and unconsolidated, in this region. A further study, with greater thoroughness, along the same lines as presented in this paper might be suggested.

A MINERAL SPECIFIC GRAVITY CHART

Kenneth K. Landes, *University of Kansas.*

Specific gravity can be used very successfully as an aid to mineral identification. Various easy and rapid methods of determining specific gravity have been developed, such as those using heavy liquids,[1] direct-reading balances,[2] and constant volume pyknometers.[3] But there has been no table or chart known to the writer giving for any determined specific gravity a list of all the common minerals with a range including that point. In order to fulfill this need the accompanying chart was prepared.[4]

Each horizontal line on the chart designates a specific gravity. The magnitude of the gravity is shown by the figure printed above each line at the right and left margin. The range of the chart is from 1.40 to 22.00. The spaces between the horizontal lines represent different amounts at different levels. Thus between 1.40 and 2.00 and between 4.00 and 5.00 the interval between the lines is .1. The interval between 2.00 and 4.00 was cut to .02, due to the preponderance of minerals with specific gravities lying between 2 and 4.[5] Between 5.00 and 10.00 the interval is 1.00 and between 10.00 and 22.00 it is 2.00. The top of the chart contains the names of 540 minerals arranged in alphabetical order. Vertical guide lines separate the mineral names and extend down to the bottom of the chart. Three styles of type were used in printing the mineral names: bold face for those most common, italics for those least common, and plain face for the intermediate group. The separation was purely arbitrary and the writer realizes that many of the minerals would be put in different classifications by other mineralogists. A vertical line stands between the guide lines beneath each mineral name and by its length and position gives the range of specific gravity for that mineral. Three weights of

---

[1] Spencer, L. J., Specific gravities of minerals: *Mineral. Mag.*, vol. **31**, pp. 337–366, 1927. Landes, K. K., Rapid specific gravity determinations with Clerici's solution: *Amer. Mineral.*, vol. **15**, pp. 159–162, 1930.

[2] Rogers, Austin F., A new specific gravity balance: *Science*, N. S., vol. **34**, pp. 58–60, 1911. Kraus, E. H., A calculating jolly balance: *Amer. Mineral.*, vol. **11**, pp. 169–172, 1926.

[3] Ellsworth, H. V., A simple and accurate constant volume pyknometer for specific gravity determinations: *Mineral. Mag.*, vol. **21**, pp. 431–435, 1928.

[4] Chart prepared through the aid of a grant from the Graduate Research Fund, University of Kansas.

[5] L. J. Spencer, *op. cit.*, p. 340.

lines are used, the heaviest for mineral names printed in bold face, the intermediate weight for mineral names printed in plain face, and the lightest for mineral names printed in italics.

Sources of specific gravity data were largely Dana's System of Mineralogy and L. J. Spencer's "Alphabetical list of minerals giving the minimum and maximum recorded values of specific gravity."[6] In a few cases original articles were consulted. The attempt was made to give the maximum range of recorded determinations for each mineral. Undoubtedly some of the determinations are inaccurate due to laboratory errors or the use of impure material in which case the ranges given on the chart may be too great. Minerals that are found only as rarities in one or two districts were omitted from the chart in order to keep it from becoming too cumbersome.

Although the chart can be used to find the approximate specific gravity of any of the 540 minerals listed it was designed to be used primarily in mineral identification. The specific gravity of an unknown mineral is determined and the line having the nearest value to that figure traced (with the aid of straight edge or ruler) across the page. It will intersect a number of vertical lines and the unknown may be any one of the minerals belonging to those lines. It is most likely, however, to be one of the minerals printed in bold or plain face whose vertical range line was intersected by the horizontal line in the middle third. A comparison of the other physical properties of the unknown with those of the suspected minerals will generally serve to complete the identification.

---

[6] *Op. cit.*, pp. 361–365.

NOTES AND NEWS

ON GRAVITY SEPARATION

R. C. Emmons., *University of Wisconsin.*

This note describes a detail of technique which has been found very helpful in making gravity separations by means of heavy liquids when the material to be separated is finely powdered. The unsatisfactory nature of gravity separation when dealing with material in a fine state of division is perhaps best accounted for by adhesion, both of grain to grain and of grains to air bubbles. Adhesion of grains to air bubbles is the result merely of the failure of the liquid to wet the grains. Mixed mineral grains, therefore, act as units sufficiently to result in considerable confusion in securing a clean separation.

In working with soil separates, it was found almost impossible to accomplish a satisfactorily clean gravity separation even with the moderately fine sands (.01 mm). Tests were made in which the liquid containing the sample was vigorously evacuated and the results were so improved that this procedure has been followed consistently since, and it has been used with equal success by other laboratories in the department of Geology at the University of Wisconsin.

The procedure is simple. It consists in attaching the vessel used for separation to a vacuum pump and slowly allowing the vacuum to increase. At first the gas evolved causes the liquid to boil and if the vacuum is increased too rapidly some of the liquid is apt to be drawn off with the resulting loss of the sample. After the first ebullition, the liquid becomes quiet, and the vacuum may be increased more rapidly. A few minutes evacuation is sufficient. Allow the liquid to stand, not necessarily under vacuum, and a rapid stratification results. Flocculent material is thus almost entirely avoided, and repeated separations are seldom necessary.

For the production of a vacuum a water aspirator is of considerable value but it does not give the clean separation of a good backing pump. A "Cenco hyvac" has been used with a great deal of satisfaction. It is necessary to have a valve between the pump and the flask for which a glass stop-cock is sufficient. A trap is also desirable to prevent any of the liquid entering the pump.

A NOTE ON THE OCCURRENCE OF MONAZITE IN WESTERN ARIZONA*

Robert E. S. Heineman, *Arizona Bureau of Mines.*

In July, 1930, Mr. A. E. Knowland, a prospector of Yucca, Arizona, sent about 40 grams of rather heavy pebbles, to the Arizona Bureau of Mines for determination. They were found by the writer to be monazite. Knowland states in a letter that the material was found scattered sparingly in stream gravels over an area of about two square miles in the Chemehuevis mining district, which is located some twenty odd miles southeast of Topock in Mohave county, Arizona.

The material was in all stages of wear from good crystals to rounded pebbles, almost all of which, however, showed vestiges of crystal faces. The crystals varied in size from minute grains to half an inch in length. In general the crystals appear to be elongated parallel to the *b*-axis. One small crystal measuring .2 of an inch along the *b*-axis showed the orthopinacoid, basal pinacoid, a positive orthodome, a prism and a positive pyramid. Accurate measurements were not made, because of the roughness of the faces.

The crystals ranged from yellow brown through red brown to dark brown in color. The specific gravity of eight crystals taken all at once with the Jolly balance was 5.04. Qualitative tests in the wet way showed the mineral to be a phosphate of the cerium group.

This occurrence is interesting inasmuch as it is the first reported monazite from Arizona.

* Published by permission of the Director, Arizona Bureau of Mines.

NEW MINERAL NAMES

Sturtite

T. Hodge-Smith: Mineralogical Notes. *Record Australian Museum*, **27**, 410–412, 1930.

Name: In honor of Captain Charles Sturt, explorer and first white man to visit Broken Hill.

Chemical Properties: A hydrous silicate of iron and manganese with other bases, $Fe_2O_3 . 6(Mn, Ca, Mg)O . 8SiO_2 . 23H_2O$. Analysis (by H. P. White): SiO_2 (free) 0.79, SiO_2 (combined) 32.35, Fe_2O_3 10.22, Al_2O_3 0.44, MnO 25.18, CaO 2.19, MgO 0.65, H_2O 28.16. Sum 99.98.

Soluble in acids with separation of granular silica. Before the blow-pipe it fuses with difficulty to a black magnetic mass. In a closed tube it gives off abundant water.

Physical Properties: Color jet black, streak yellowish brown. Luster vitreous inclining to greasy. Hardness over 3. Sp. Gr. $=2.054$. Amorphous, fracture subconchoidal to uneven. Very brittle. In a thin section it is isotropic, transparent and is pale brown in color.

Occurrence: Found associated with quartz, amethystine quartz, spessartite, rhodochrosite, calcite, galena, and sphalerite; also rhodonite and manganhedenbergite at the Zinc Corporation mine, Broken Hill, N. S. W.

W. F. Foshag

Elbrussite

I. J. Mickey: Ueber eine neue Mineralart aus der Gruppe Nontronit-Beidellit (A new mineral variety belonging to the nontronite-beidellite group). *Centr. Min. Geol.*, 1930, Abt. A, No. **7**, p. 293–303, 1930.

Name: From the mountain Elbruss near which it is found.

Chemical Properties: A hydrous silicate of aluminum and ferric iron. Analysis (by G. M. Scherschever): SiO_2 39.74; Al_2O_3 14.44; Fe_2O_3 7.44; FeO 6.90; CaO 0.55 MgO 5.11; alkalies (as K_2O) 2.80; H_2O (110°) 17.69.

Fusible at 3 to a white, nonmagnetic bead.

Physical and Optical Properties: Color dark chocolate brown, on cut surface streaked white and dark brown. Streak dark lemon yellow. $H=2$, Sp. Gr. $=2.281$. Adheres to the tongue. Uniaxial. $n=1.56$. Not pleochroic or very weakly so. In thin section shows a *moire* structure.

Occurrence: As a small vein in the liparite-pumice tuffs at Tschuhtschur River, Karatschaev region, N. Caucasus.

W. F. F.

Bianchite

C. Andreatta: Bianchite, nuovo minerale (Bianchite, a new mineral). *Rend. Accad. Lincei,* (6), **41,** 760–769, 1930.

Name: In honor of Prof. Angelo Bianchi, (Padova).

Chemical Properties: A hydrated sulphate of zinc and iron, $FeZn_2(SO_4)_3 \cdot 18H_2O$. An analysis by Andreatta gave: FeO 8.84, Fe_2O_3 n.d., CaO trace, ZnO 20.01, MgO trace, SO_3 30.13, H_2O 39.92, Insol. 1.02; Sum 99.93. Soluble in cold water. The dehydration was studied: at 150° the stable hydrate, $FeZn_2(SO_4)_3 \cdot 2H_2O$, is formed. All H_2O is lost at 260°.

Crystallographic Properties: Probably monoclinic, confirmed by X-ray study. No crystal measurements were possible.

Physical and Optical Properties: White, "resembles goslarite." Under the microscope it shows minute aggregates. Optically negative; $\alpha = 1.4652$, $\beta = 1.4942$, $\gamma = 1.4946$; $\gamma - \alpha = .0294$. Optic axial angle variable, always small; maximum, observed, $2V = 10°$; calculated, $2V = 13° 26'$. Dispersion weak, $\rho > v$.

Occurrence: Forms crusts in artificial caves at the mines at Raibl, Trentino.

H. S. Washington